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ORIGINAL ARTICLE

Association of body mass index and gross national income with caries experience in children in 117 countries

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ABSTRACT

Objective: To evaluate the association of body mass index (BMI) and gross national income (GNI) per capita with dental caries experience in children at population levels.

Methods: This ecological study used global data of decay, missing, and filled teeth (DMFT), BMI, and GNI. DMFT data of 12 years old children from 117 countries were obtained from the World Health Organization. BMI data of children and adolescents from the same 117 countries were retrieved from the NCD Risk Factor Collaboration and GNI per capita from the World Bank. ANOVA test, Pearson's correlation coefficient (r), and multivariable linear regression were performed.

Results: Globally mean BMI ranged from 16.1 to 22.2 in children. Low-income countries had the lowest BMI (17.41 ± 0.57) and high-income countries had the highest BMI (20.14 ± 0.87) ($p < .001$). The highest mean DMFT was observed in upper-middle-income countries (2.48 ± 1.16) and the lowest in low-income countries (1.22 ± 0.83) ($p = .001$). There was no significant correlation between BMI and dental caries (DMFT) ($r = .063$; $p = .498$). However, there were significant correlations between GNI per capita and BMI ($r = 0.366$; $p < .001$) and GNI per capita and DMFT ($r = -0.252$; $p = .007$). In multivariable linear regression, GNI per capita was negatively associated with caries experience in children (B = −1.83; $p < .001$).

Conclusion: The study found that BMI was associated with income levels of the countries. GNI per capita significantly and negatively correlated with DMFT in children. Further investigation into the association between BMI and dental caries is warranted.

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Body mass index; dental caries; income; adolescents; ecological study

Introduction

Globally, there was a dramatic ten times increase in the prevalence of obesity in children and adolescents from 1975 to 2016 [1]. According to the World Health Organization global estimates, there were 340 million obese or overweight children and adolescents (5–19 years) in 2016 [2]. Childhood obesity increases the risk of type 2 diabetes, high blood pressure, and coronary heart disease [3]. In addition, obese children are more susceptible to adverse psychological outcomes and low educational performance [4,5]. It is known that overweight in children and adolescents is likely to persist and result in overweight and obesity in adulthood because it is difficult for children to lose weight and maintain weight loss [6].

Complex interplay of genetic, environmental, and behavioural factors can result in obesity in children and adolescents [7]. The biological, social, and behavioural risk factors associated with childhood obesity operate within family environment of children and are further modified by community environment [8]. Generally, excess dietary intake, lack of physical activity, sedentary behaviours are important determinants of obesity [9]. In most parts of the world, obesity in children and adolescents has increased during the last four decades [10]. It was reported that excess weight in children and adolescents continued to increase in low and middle income countries, but it plateaued in high-income countries during 1980–2013 [11].

In 2015, 2.4 billion people had untreated caries in permanent teeth (prevalence 34.1%) and it was the most prevalent condition among all conditions included in the Global Burden of Disease study. The prevalence of untreated caries in permanent dentition was the highest in adolescents and declined with advancing age [12]. Available evidence suggests that dental caries causes the destruction of tooth structure which can lead to the formation of cavities, pain, and negative impact on the quality of life [13].

Evaluation of risk factors at the population level provides valuable information in addition to the factors which operate at the individual level [14]. A previous ecological study showed an inverse correlation between gross national income (GNI) per capita with dmft index in 5–6 years old children in 48 rich countries [15]. A study by Masood et al. [16] showed that income level of the country modified the association between per capita consumption of sugar and caries in 12 years old children. In a recent study, El Tantawi et al. [17] observed an association between the growth of GNI and

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early childhood caries in 3–6 years of children in 88 countries.

In health promotion, social-ecological perspective is used to better understand health problems and develop possible preventive strategies. The social-ecological perspective involves complex interaction of personal, social, and public policy factors [18]. In the present study, personal level socio-ecological factors were used to assume that variation in GNI per capita and BMI estimates would influence country level caries experience in children. This would help in developing country-level caries prevention strategies.

Income and obesity are important factors associated with dental caries which is a multifactorial condition [9,17]. There are conflicting reports about the association between BMI and dental caries in children and adolescents [19]. In addition, data are scant about the association between BMI and dental caries in children and adolescents at the population/country level. Similarly, evidence is scarce about an association between GNI per capita and caries experience in children globally. Therefore, this study aimed to evaluate the association of BMI and GNI per capita with caries experience (DMFT) in children and adolescents around the world. The study assessed the associations of two main socio-ecological factors (BMI estimates of children and income of the country reflected through GNI per capita) with caries experience in children globally.

Methods

The study was approved by the ethics committee at the College of Dentistry, Imam Abdulrahman Bin Faisal University, Dammam, Saudi Arabia (E A 2019045). GNI per capita was used as a proxy for the level of income of individuals in each country. GNI of each country was retrieved from the World Bank (2017) [20]. In addition, based on a GNI per capita, the bank classified all the countries into low-income (<$996), lower-middle-income ($996–3895), upper-middle-income ($3896–12,055), and high-income ($12,056 or more) countries.

The World Health Organization maintains the database of caries experience (DMFT) in 12 years old children from the countries around the world and this DMFT data were used in our study [21]. The database included the information about DMFT from studies conducted in 193 countries since the year 1973. However, DMFT data from the year 2000 to 2017 ($n = 117$ countries) were included in our study. The data from 1973 to 1999 were excluded from the study.

Body mass index (BMI) is used to assess the level of fat in the body to define overweight and obesity which result from abnormal or excessive fat deposition [22]. This weight-for-height index measures weight in kilograms of a person divided by the square of his/her height in metres (kg/m2) [2]. Global estimates about body mass index in children and adolescents (5 to 19 years) are maintained by NCD Risk Factor Collaboration [10]. Although, data of BMI and GNI per capita are available from 200 and 183 countries, respectively. However, data of BMI and GNI per capita were included from the same 117 countries which had DMFT information.

Microsoft Excel (2010) was used to enter data from selected countries and bar graphs were produced. Statistical analyses were performed using Statistical Package for Social Science (SPSS Statistics for Windows, Version 22.0, IBM Corp, Armonk, NY). The pooled estimates of BMI and DMFT were evaluated by displaying data in horizontal bar charts. The comparisons of DMFT and BMI in low-income, lower-middle-income, upper-middle income, and high-income countries were performed using one way ANOVA test. Pearson's correlation coefficient (r) was calculated to evaluate correlation between BMI and DMFT, GNI per capita and DMFT, and GNI per capita and BMI. Multiple linear regression was performed to test the association between DMFT and BMI and GNI per capita. GNI per capita and BMI estimates from selected countries were used as important socio-ecological indicators of caries experience [15,17]. Significance level of $\leq .05$ was used for statistical testing.

Results

Among low-income countries, the lowest BMI (16.1) in children and adolescents was in Ethiopia while the highest BMI (17.9) was in Yemen. Tanzania had the lowest estimates of DMFT (0.3) and Afghanistan had the highest DMFT of 2.6 followed by Nepal with a DMFT score of 2.3 (Figure 1). Data of DMFT and BMI in lower-middle-income countries are shown in Figure 2. Egypt had the highest score of BMI (21.2) among lower-middle-income countries. India, Bangladesh, Cambodia, and Myanmar had the lowest BMI of 17. Nigerian children demonstrated the least caries experience (DMFT 0.04) while Cambodian children showed increased caries experience (DMFT 5.5). Cambodian children had the lowest BMI but the highest DMFT.

Upper-middle-income countries showed varying patterns of BMI and DMFT (Figure 3). Children in Cuba showed the

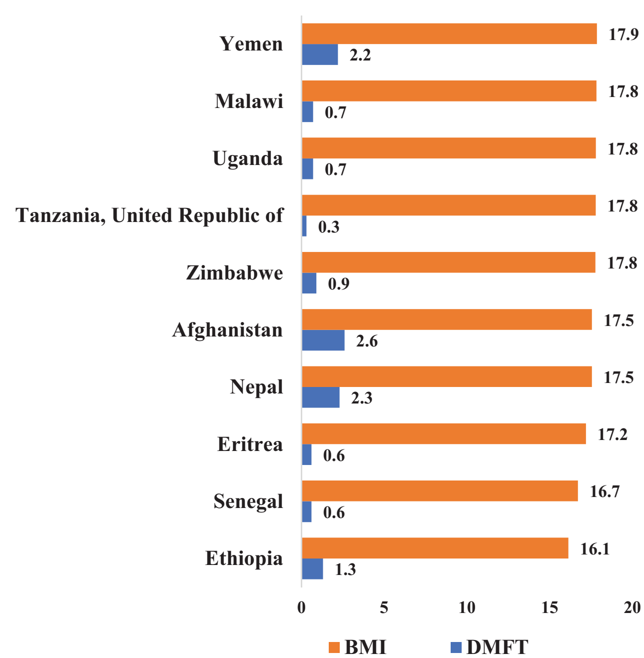

Figure 1. BMI and caries experience in children in low income countries.

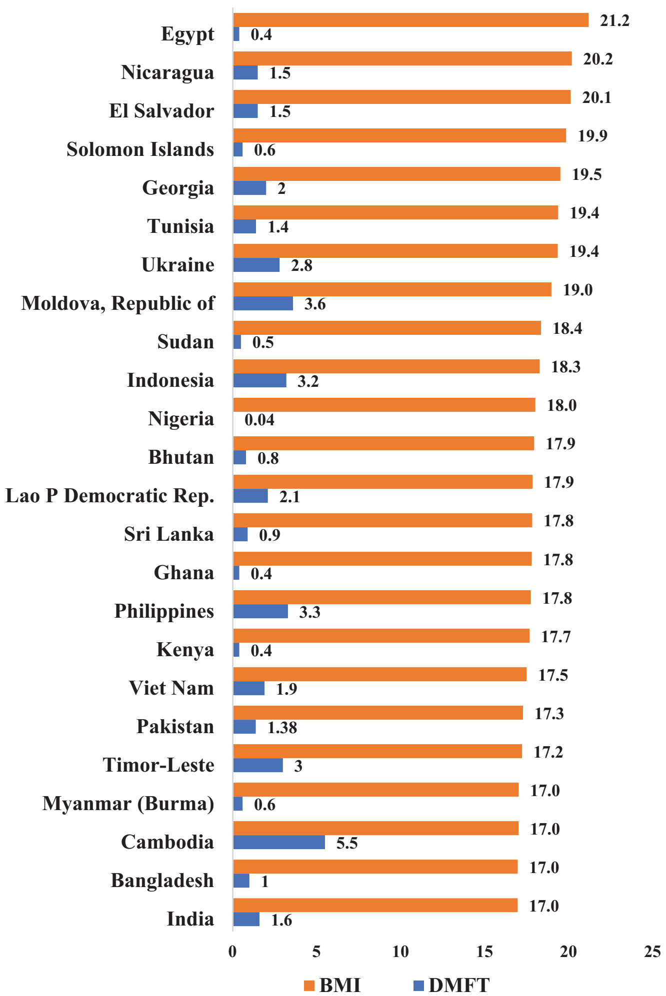

Figure 2. BMI and caries experience in children in lower middle income countries.

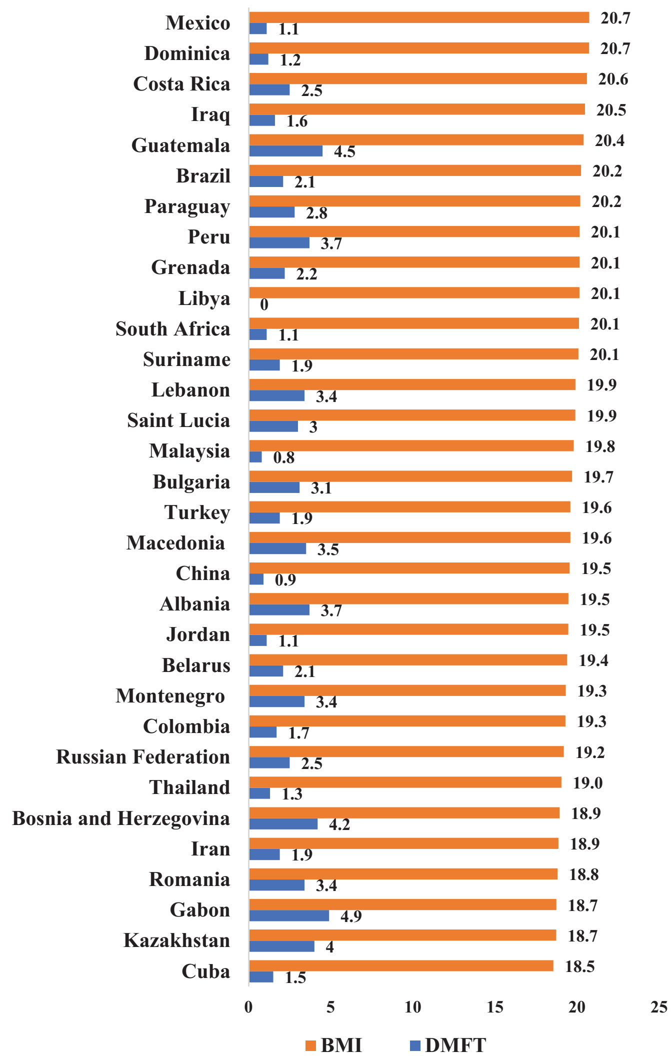

Figure 3. BMI and caries experience in children in upper middle income countries.

lowest BMI (18.5), followed by Kazakhstan and Gabon (BMI = 18.7). DMFT estimates were the highest in Gabon (DMFT = 4.9), Guatemala (DMFT = 4.5), Bosnia Herzegovina (DMFT = 4.2) and Kazakhstan (DMFT = 4). Among upper-middle-income countries, children in Gabon and Kazakhstan had high BMI and DMFT scores. Figure 4 shows the distribution of DMFT and BMI among high-income countries. Children in Japan had the lowest DMFT (0.2) and BMI (18.7). The highest distribution of BMI was in Bahamas (22.2), Kuwait (22.1) and Chile (22) (Figure 4). Of all the countries analysed, BMI ranged from 16.1 to 22.2 (mean 19.41 ± 1.25). Similarly, minimum DMFT was 0.04 and maximum was 5.5 and mean DMFT was 1.79 ± 1.13.

Table 1 shows the distribution of BMI and DMFT in children in low-income, lower-middle-income, upper-middle-income and high-income countries. Mean BMI was the lowest in low-income countries (17.41 ± 0.57) and the highest in high-income countries (20.14 ± 0.87) ($p < 0.001$). The highest mean DMFT was observed in upper-middle-income countries (2.48 ± 1.16) and the lowest in low-income countries (1.22 ± 0.83) and there were statistically significant differences among these countries ($p = .001$).

There was a positive and moderate correlation between GNI per capita and BMI ($r = 0.366$) which was statistically significant ($p < .001$). There was a significant, negative and weak correlation between DMFT and GNI per capita ($r = -0.252$; $p = .007$) (Table 2). Multiple linear regression analyses showed that GNI per capita was significantly associated with caries experience in children. For each unit higher GNI per capita, there was a lower DMFT ($B = -1.831$; $p < .001$). On the other hand, BMI showed no significant association with caries experience in children ($B = 0.119$; $p = .147$) (Table 3).

Discussion

Obesity and dental caries are well-known public health problems among adolescents around the globe [6,22]. Many factors particularly income play a substantial role in obesity and dental caries [17,23]. The literature provides evidence for an association between economic growth indicators and obesity [23]. Similarly, our analysis confirmed that mean BMI in low-income countries was lowest and highest in high-income countries. Our study also observed a positive correlation between GNI per capita and BMI in children and adolescents from 117 countries. These findings are similar to the results of a study of 206,266 persons from 70 low, middle and high-income countries where each unit increase in GNI per capita was associated with a unit increase in BMI [24]. Egger et al. [23] analysed BMI data and gross domestic product (GDP) from 175 countries and observed a positive correlation between GDP and BMI in adults populations.

At the individual level, there is a direct relationship between household income and BMI in adolescents [25]. Increased likelihood of childhood overweight and obesity is associated with per-capita household income [26]. It is well documented that individuals with high household income have greater affordability of food and high purchasing power [27]. Similarly, leisure pursuit and sedentary lifestyle including transport are common in high-income families. That is why children with low-income background may be protected from obesity or overweight because of their inability to purchase costly processed food [26].

The literature consistently reports an association of obesity with dental caries in adolescents. Sugar intake including sugar-sweetened drinks and frequency of food intake between meals may increase the risk of dental caries and childhood obesity which may account for the link between both conditions [28]. In a multivariable logistic regression model, Modéer et al. [29] showed significantly higher odds of decayed surfaces (OR 1.31) with BMI in adolescents. Similarly, a study by Thippeswamy et al. [30] indicated a significant association between overweight/obesity and DMFT. It was found that obese/overweight children were 3.68 times more likely to have high caries experience than normal weight children. Similarly, two cross-sectional studies demonstrated negative association between BMI and caries in children [31,32]. Two systematic reviews also did not provide enough evidence to support an association between obesity and dental caries [22,33]. Current evidence related to the association of caries and BMI is still inconsistent [34]. Similarly, multivariable linear regression in our study showed no significant relationship of BMI with caries experience.

Dental caries is mostly concentrated among individuals from low-income groups and an inverse relationship exists between family income and caries. This has been demonstrated in a recent systematic review of 48 studies which showed that the children of high-income parents had a low risk of caries [35]. Previous ecological analyses evaluated the influence of gross national income or gross domestic income on dental caries [17,36]. In an ecological study of 44 rich countries, GNI inversely correlated with caries experience of 5–6 years old children [15]. A similar study included data from 88 countries and demonstrated that one percent growth in GNI was associated with higher prevalence of caries in 36–71 months old children [17]. Another study observed that GNI modified the association between caries and sugar consumption. The authors also reported that GNI was highly significantly associated with DMFT in both low-income and high-income countries [16]. Likewise, the present study found a significant and negative correlation between GNI per capita and caries. Multivariable linear regression also

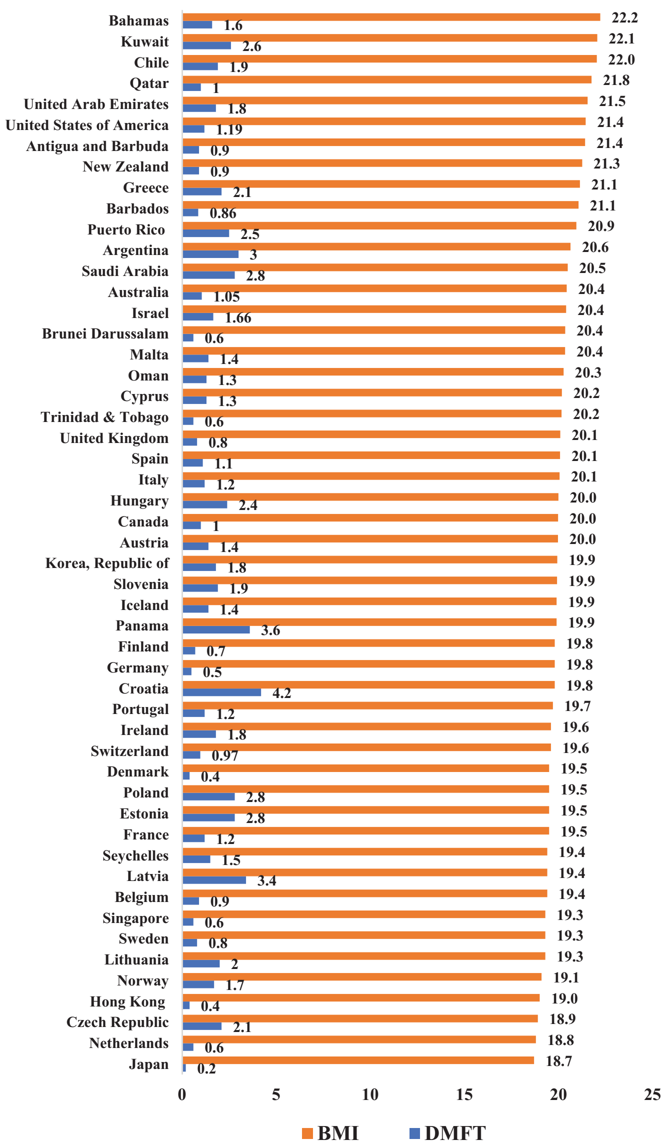

Figure 4. BMI and caries experience in children in high income countries.

Table 2. Bivariate analysis: correlation between BMI and DMFT, GNI per capita and BMI, and GNI per capita and DMFT in children.

	Pearson's correlation coefficient	*p* Value
Correlation between BMI and DMFT	0.063	.498
Correlation between BMI and GNI	0.366	<.001*
Correlation between GNI and DMFT	−0.252	.007*

*Significant at .05 level.

Table 1. BMI and DMFT in children from 117 selected countries.

Variables	Low-income countries ($N = 10$)	Lower-middle-income countries ($N = 24$)	Upper-middle-income countries ($N = 32$)	High-income countries ($N = 51$)	*p* Value
Mean BMI	17.41 ± 0.57	18.34 ± 1.12	19.67 ± 0.62	20.14 ± 0.87	<.001*
DMFT	1.22 ± 0.83	1.68 ± 1.32	2.48 ± 1.16	1.54 ± 0.89	.001*

*Significant at .05 level.

Table 3. Multivariable liner regression analyses: role of BMI and GNI on caries experience in children in selected countries.

	Coefficients				
	Unstandardized coefficients		Standardized coefficients		
Independent variables	*B* (95.0% confidence interval)	SE	β coefficient	*T*	*p* Value
BMI	0.119 (−0.057, 0.295)	0.089	0.132	1.340	.147
GNI per capita	−1.831 (−2.649, −1.013)	0.413	−0.300	−3.051	<.001*

*Significant at the .05 level.

showed that higher GNI per capita was significantly associated with lower DMFT in our analysis. On the other hand, Bernabé et al. [36] demonstrated no significant correlation between DMFT and GDP and GNI in adults from 18 rich countries.

The study findings added new information to the existing knowledge base about income level, BMI, and dental caries. This information may help stakeholders develop policies to prevent obesity and dental caries which are public health problems in children. Our study findings are limited due to ecologic fallacy. Three data sets obtained from selected countries can vary in quality and can limit the generalizability of the study results. Not all data used in our analysis were from national studies. DMFT data from 1973 to 1999 were excluded to make as reasonable comparison as possible with GNI (2017) and BMI (2016). However, this could lead to the loss of important information about caries experience. Similarly, caution is needed when interpreting correlation of DMFT data of 12 years children with BMI data of children and adolescents (5–19 years).

Some ecological studies have reported associations of different country level socio-ecological factors such national income level, financial crisis, gender inequality, urban population, mean years of schooling, and internet use with life expectancy [18,37,38]. On the other hand, ecological studies similar to our study observed the association of income and income inequality with caries [15,16,36]. Other socio-ecological factors should be addressed in future research by evaluating the association of gender inequality, years of schooling, per capita sugar consumption with caries experience. Current literature shows inconsistencies about an association between dental caries and BMI [34]. Nevertheless, the evidence is growing about an association between obesity and dental caries which remains an interesting topic for future research.

Prevention and control of global epidemics of obesity and dental caries require integrated actions taken in healthcare systems, financial sectors, trade, media, agriculture, and civil society to create healthy food environment and to provide funding for preventive strategies.

Conclusion

The study showed a significant positive correlation between BMI and GNI per capita. The GNI per capita significantly and negatively correlated with DMFT. Higher GNI per capita was associated with lower DMFT in children. The association between BMI and DMFT should be further investigated using a robust study design conducted at various international locations.

Disclosure statement

No potential conflict of interest was reported by the authors.

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